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X. *An Account of the Application of the Gas from Coal to economical Purposes.* By Mr. William Murdoch. Communicated by the Right Hon. Sir Joseph Banks, Bart. K. B. P. R. S.

Read February 25, 1808.

THE facts and results intended to be communicated in this Paper, are founded upon observations made, during the present winter, at the cotton manufactory of Messrs. PHILIPS and LEE at Manchester, where the light obtained by the combustion of the gas from coal is used upon a very large scale ; the apparatus for its production and application having been prepared by me at the works of Messrs. BOULTON, WATT, and Co. at Soho.

The whole of the rooms of this cotton mill, which is, I believe, the most extensive in the United Kingdom, as well as its counting-houses and store-rooms, and the adjacent dwelling-house of Mr. LEE, are lighted with the gas from coal. The total quantity of light used during the hours of burning, has been ascertained, by a comparison of shadows, to be about equal to the light which 2500 mould candles of six in the pound would give ; each of the candles, with which the comparison was made consuming at the rate of $\frac{4}{10}$ ths of an ounce (175 grains) of tallow per hour.

The quantity of light is necessarily liable to some variation, from the difficulty of adjusting all the flames, so as to be perfectly equal at all times ; but the admirable precision and

exactness with which the business of this mill is conducted, afforded as excellent an opportunity of making the comparative trials I had in view, as is perhaps likely to be ever obtained in general practice. And the experiments being made upon so large a scale, and for a considerable period of time, may, I think, be assumed as a sufficiently accurate standard for determining the advantages to be expected from the use of the gas lights under favourable circumstances.

It is not my intention, in the present Paper, to enter into a particular description of the apparatus employed for producing the gas; but I may observe generally, that the coal is distilled in large iron retorts, which during the winter season are kept constantly at work, except during the intervals of charging; and that the gas, as it rises from them, is conveyed by iron pipes into large reservoirs, or gazometers, where it is washed and purified, previous to its being conveyed through other pipes, called mains, to the mill. These mains branch off into a variety of ramifications (forming a total length of several miles), and diminish in size, as the quantity of gas required to be passed through them becomes less. The burners, where the gas is consumed, are connected with the above mains, by short tubes, each of which is furnished with a cock to regulate the admission of the gas to each burner, and to shut it totally off when requisite. This latter operation may likewise be instantaneously performed, throughout the whole of the burners in each room, by turning a cock, with which each main is provided, near its entrance into the room.

The burners are of two kinds: the one is upon the principle of the ARGAND lamp, and resembles it in appearance; the other is a small curved tube with a conical end, having

three circular apertures or perforations, of about a thirtieth of an inch in diameter, one at the point of the cone, and two lateral ones, through which the gas issues, forming three divergent jets of flame, somewhat like a fleur-de-lis. The shape and general appearance of this tube, has procured it among the workmen, the name of the cockspur burner.

The number of burners employed in all the buildings, amounts to 271 ARGANDS, and 633 cockspurs; each of the former giving a light equal to that of four candles of the description abovementioned; and each of the latter, a light equal to two and a quarter of the same candles; making therefore the total of the gas light a little more than equal to that of 2500 candles. When thus regulated, the whole of the above burners require an *hourly* supply of 1250 cubic feet of the gas produced from cannel coal; the superior quality and quantity of the gas produced from that material having given it a decided preference in this situation, over every other coal, notwithstanding its higher price.

The time during which the gas light is used, may, upon an average of the whole year, be stated at least at two hours per day of twenty-four hours. In some mills, where there is over work, it will be three hours; and in the few where night-work is still continued, nearly twelve hours. But taking two hours per day as the common average throughout the year, the consumption in Messrs. PHILIPS' and LEE's mill, will be $1250 \times 2 = 2500$ cubic feet of gas per day; to produce which, seven hundred weight of cannel coal is required in the retort. The price of the best Wigan cannel (the sort used) is $13\frac{1}{2}d.$ per cwt. ($22s. 6d.$ per ton), delivered at the mill, or say about eight shillings for the seven hundred weight. Multiplying by

the number of working days in the year (313), the annual consumption of cannel will be 110 tons, and its cost £125.

About one-third of the above quantity, or say forty tons of good common coal, value ten shillings per ton, is required for fuel to heat the retorts; the annual amount of which is £20.

The 110 tons of cannel coal when distilled, produce about 70 tons of good coak, which is sold upon the spot at 1s. 4d. per cwt. and will therefore amount annually to the sum of £93.

The quantity of tar produced from each ton of cannel coal is from eleven to twelve ale gallons, making a total annual produce of about 1250 ale gallons, which not having been yet sold, I cannot determine its value; but whenever it comes to be manufactured in large quantities, it cannot be such as materially to influence the economical statement, unless indeed new applications of it should be discovered.

The quantity of aqueous fluid which came over in the course of the observations which I am now giving an account of, was not exactly ascertained, from some springs having got into the reservoir; and as it has not been yet applied to any useful purpose, I may omit further notice of it in this statement.

The interest of the capital expended in the necessary apparatus and buildings, together with what is considered as an ample allowance for wear and tear, is stated by Mr. LEE at about £550. per annum: in which some allowance is made for this apparatus being made upon a scale adequate to the supply of a still greater quantity of light, than he has occasion to make use of.

He is of opinion, that the cost of attendance upon candles would be as much, if not more, than upon the gas apparatus; so that in forming the comparison, nothing need be stated upon that score, on either side.

The economical statement for one year then stands thus :

Cost of 110 tons of cannel coal	-	£125.
Ditto of 40 tons of common ditto	-	20

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Deduct the value of 70 tons of coak	-	93
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The annual expenditure in coal, after deducting the value of the coak, and without allowing any thing for the tar, is therefore - 52

And the interest of capital, and wear and tear of apparatus - - - 550

making the total expence of the gas apparatus, about £600. per annum.

That of candles, to give the same light, would be about £2000. For each candle consuming at the rate of 4-10ths of an ounce of tallow per hour, the 2500 candles burning upon an average of the year two hours per day, would, at one shilling per pound, the present price, amount to nearly the sum of money abovementioned.

If the comparison were made upon an average of three hours per day, the advantage would be still more in favour of the gas light; the interest of the capital, and wear and tear of the apparatus continuing nearly the same as in the former case; thus,

$1250 \times 3 = 3750$ cubic feet of gas per day, which would be produced by $10\frac{3}{4}$ cwt. of cannel coals; this multiplied by the

number of working days, gives 168 tons per annum, which valued as before, amounts to - - £188.

And 60 tons common coal for burning under the retorts, will amount to - - 30

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Deduct 105 tons of coak at 26s. 8d. - 140

Leaving the expenditure in coal, after deduction of the coak, and without allowance for the tar, at - - - 78

Adding to which the interest and wear and tear of apparatus, as before, the total annual cost will not be more than £650. whilst that of tallow, rated as before, will be £3000.

It will readily occur, that the greater number of hours the gas is burnt, the greater will be its comparative economy; although in extending it beyond three hours, an increase of some parts of the apparatus would be necessary.

If the economical comparison were made with oils, the advantages would be less than with tallow.

The introduction of this species of light into the establishment of Messrs. PHILIPS and LEE, has been gradual; beginning in the year 1805, with two rooms of the mill, the counting-houses, and Mr. LEE's dwelling-house. After which, it was extended through the whole manufactory, as expeditiously as the apparatus could be prepared.

At first, some inconvenience was experienced from the smell of the unconsumed, or imperfectly purified gas, which may in a great measure be attributed to the introduction of successive improvements in the construction of the apparatus, as the work proceeded. But since its completion, and since the persons to

whose care it is confided, have become familiar with its management, this inconvenience has been obviated, not only in the mill, but also in Mr. LEE's house, which is most brilliantly illuminated with it, to the exclusion of every other species of artificial light.

The peculiar softness and clearness of this light, with its almost unvarying intensity, have brought it into great favour with the work people. And its being free from the inconvenience and danger, resulting from the sparks and frequent snuffing of candles, is a circumstance of material importance, as tending to diminish the hazard of fire, to which cotton mills are known to be much exposed.

The above particulars, it is conceived, contain such information, as may tend to illustrate the general advantages attending the use of the gas light; but nevertheless the Royal Society may perhaps not deem it uninteresting to be apprized of the circumstances which originally gave rise in my mind to its application, as an economical substitute for oils and tallow.

It is now nearly sixteen years, since, in a course of experiments I was making at Redruth in Cornwall, upon the quantities and qualities of the gases produced by distillation from different mineral and vegetable substances, I was induced by some observations I had previously made upon the burning of coal, to try the combustible property of the gases produced from it, as well as from peat, wood, and other inflammable substances. And being struck with the great quantities of gas which they afforded, as well as with the brilliancy of the light, and the facility of its production, I instituted several experiments with a view of ascertaining the cost at which it might

be obtained, compared with that of equal quantities of light yielded by oils and tallow.

My apparatus consisted of an iron retort, with tinned copper and iron tubes through which the gas was conducted to a considerable distance; and there, as well as at intermediate points, was burned through apertures of varied forms and dimensions. The experiments were made upon coal of different qualities, which I procured from distant parts of the kingdom, for the purpose of ascertaining which would give the most economical results. The gas was also washed with water, and other means were employed to purify it.

In the year 1798, I removed from Cornwall to Messrs. BOULTON, WATT, and Co's. works for the manufactory of steam engines at the Soho Foundry, and there I constructed an apparatus upon a larger scale, which during many successive nights was applied to the lighting of their principal building, and various new methods were practised, of washing and purifying the gas.

These experiments were continued with some interruptions, until the peace of 1802, when a public display of this light was made by me in the illumination of Mr. BOULTON's manufactory at Soho, upon that occasion.

Since that period, I have, under the sanction of Messrs. BOULTON, WATT, and Co. extended the apparatus at Soho Foundry, so as to give light to all the principal shops, where it is in regular use, to the exclusion of other artificial light; but I have preferred giving the results from Messrs. PHILIPS' and LEE's apparatus, both on account of its greater extent, and the greater uniformity of the lights, which rendered the comparison with candles less difficult.

At the time I commenced my experiments, I was certainly unacquainted with the circumstance of the gas from coal having been observed by others to be capable of combustion ; but I am since informed, that the current of gas escaping from Lord DUNDONALD'S tar ovens had been frequently fired ; and I find that Dr. CLAYTON, in a Paper in Volume XLI. of the Transactions of the Royal Society, so long ago as the year 1739, gave an account of some observations and experiments made by him, which clearly manifest his knowledge of the inflammable property of the gas, which he denominates " the spirit of coals ;" but the idea of applying it as an economical substitute for oils and tallow, does not appear to have occurred to this gentleman, and I believe I may, without presuming too much, claim both the first idea of applying, and the first actual application of this gas to economical purposes.